NEW ROLES FOR UUVS IN INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

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ABSTRACT

Intelligence, Surveillance, and Reconnaissance (ISR) is a key mission area for today's military applications. While this involves all types of platforms on land, air, and sea, the emerging capabilities of Unmanned Underwater Vehicles (UUVs) provide a new dimension to ISR operations. In the recently completed Navy UUV Master Plan, ISR was the number one ranked capability for future UUV development. On-going efforts at the Space and Naval Warfare Systems Center (SSC) San Diego combine expertise in both ISR and UUV systems to meet these emerging requirements. The technologies and systems involved in implementing these missions are discussed, emphasizing developments in sensors, communications and system autonomy.

I. OVERVIEW

The battlespace of today encompasses air, land and sea domains, requiring full sensor coverage and communication across all boundaries. Intelligence, Surveillance, and Reconnaissance (ISR) is a key mission in today's world. The goal of the mission is to provide the warrior with the tools to achieve information dominance over real and potential adversaries. To do this, a wide variety of disparate units and functions must be integrated into coordinated operational capabilities. The mission at Space and Naval Warfare Systems Center San Diego (SSC-San Diego) is focussed on the implementation and the effective use of these functions and capabilities. SSC-San Diego is the Navy's research, development, test and evaluation, engineering, and fleet support center for command and control, communications, ocean surveillance, and the integration of those systems which overarch multiple platforms. This provides a unique perspective for the development and employment of unmanned undersea vehicle applications for ISR (Figure 1).

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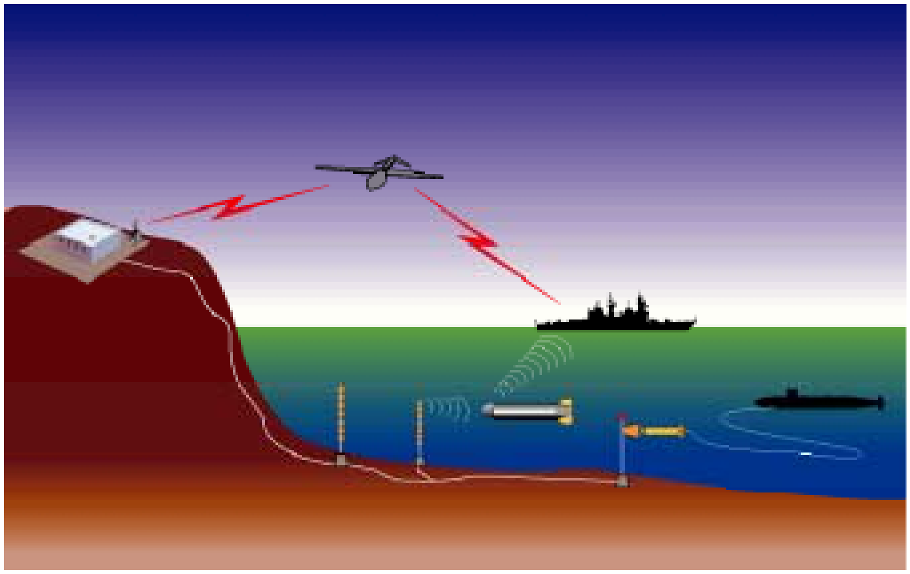


Figure 1: UUVs for Intelligence, Surveillance and Reconnaissance

A. The ISR Mission

Inside the large mission area of ISR, there are a number of tasks well suited to implementation by unmanned undersea vehicles (Figure 2). At the base of the pyramid is the collection of data, usually by sensors deployed at the sites of interest. Next, the data must be communicated to a central location where it is integrated with other data and interpreted within the context of the situation. Based on the interpretation, decisions are made as to the appropriate actions to be taken. Finally, the action is implemented, often requiring verification, which in turn is provided by sensors, restarting the cycle.

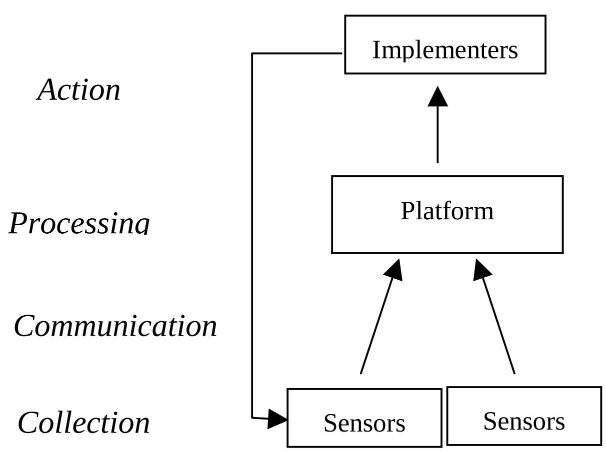


Figure 2: ISR Tasks

B. UUV Solutions

Unmanned vehicle systems play a key role in many of these ISR tasks. They are an effective means of deploying surveillance sensors in air, land, and sea, providing the data required for comprehensive situation awareness and understanding. Various communications modes are facilitated with vehicle systems, be it underwater or over the horizon, providing connectivity without exposing troops or platforms to hazardous situations. Vehicles are also key in cross-platform integration, bringing shore-based data to offshore platforms and vice-versa. Compatible and integrated systems are essential for the continued evolution and performance of these missions.

II. UUV SYSTEMS

The *Navy Unmanned Undersea Vehicle (UUV) Master Plan* ranks the ISR mission of Maritime Reconnaissance as the number one priority mission to be addressed by UUVs in the Navy. Use of UUVs as sensor platforms confers multiple advantages in today's net-centric scenario. First and foremost is the extended reach possible using a vehicle. An autonomous system is not limited by a tether or other communication constraints. Second, the independence of an autonomous system allows it to operate discretely, with minimal exposure of manned assets. Combined with the reach, this means that an autonomous system may now penetrate previously denied or unsafe areas. Finally, continuing development of UUV technology is leading to the ability to deploy multiple systems, resulting in an extended network of sensors able to provide critical data in a timely fashion. SSC-SD has developed a number of systems and enabling technologies directed at achieving these goals.

A. Sensor Platforms

SSC-SD has developed a wide variety of UUVs over the past 30 years, starting with their pioneering experience in remotely operated vehicles. Systems such as the CURV, Nozzle Plug, Mine Neutralization Vehicle, and Advanced Tethered Vehicle have provided a strong technology and application base for advanced system development. Two of the most advanced UUV platforms developed are the Free Swimmer and the Advanced Unmanned Search System.

<u>Free Swimmer</u>: Two Free Swimmer vehicles were produced by SSC-SD in the Experimental Autonomous Vehicle program, funded by the US Geologic Survey in the early 1980's. As testbeds, they demonstrated a wide variety of advanced concepts and technologies including autonomous pipeline following, supervisory control, autonomous mission planning, neural network controlled sensor, manipulator coordination, expendable fiber optic links, acoustic navigation, and underwater wet-mateable fiber optic connectors. While the free-swimmer vehicles themselves are currently inactive, the technologies developed with them are evident throughout the vehicle community.

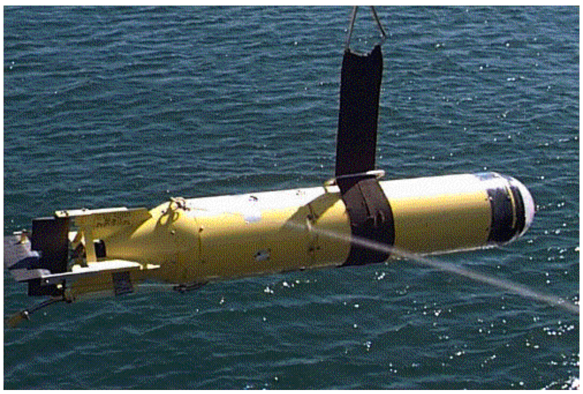
Advanced Unmanned Search System (AUSS): The need for a deep ocean search capability drove the development of AUSS, demonstrated in 1992. Unhampered by a physical tether, AUSS uses an acoustic data link for supervisory control of the vehicle. All critical vehicle and mission control loops are closed on the vehicle, allowing autonomous performance of basic mission tasks such as transiting to a given location, hovering, and executing pre-programmed sonar and optical search patterns. Sensor data from the onboard side-looking sonar, forward looking sonar, and electronic still camera is compressed and acoustically transmitted to the surface. At any time, the surface operator may designate a target for closer investigation. If it proves to be a false target, the search may be easily resumed. Designed to operate to a depth of 20,000 feet, the AUSS vehicle is 17' long, 31" diameter, with a cylindrical graphite epoxy pressure hull with titanium hemispherical ends. During sea tests in 1992, AUSS demonstrated side-looking sonar search at 5 knots, detailed optical inspection, sustained search rates up to one square nautical mile per hour, and operation at a depth of 12,000 feet. The system remains on standby for any potential requirements.

Figure 3: The Advanced Unmanned Search System (AUSS)

B. Communication Links

One of the emerging roles for autonomous systems is that of communication relays within the grid of sensors deployed for ISR. As with the sensor platform role, use of autonomous vehicles confers multiple advantages. Their extensive reach permits timely communication with remote sites without undue exposure of platforms. This is equally effective for a submarine communicating with an undersea sensor grid or a ground base communicating over the horizon to forward deployed troops. SSC-SD is currently investigating a myriad of ways that vehicles can function as communication links within the context of larger systems being developed.

Flying Plug: The Flying Plug vehicle system (Figure 4) was developed as a means of transmitting large quantities of data underwater via the expendable fiber optic micro cable. A small vehicle, the Flying Plug is launched from a support platform, paying out micro cable as it goes. Control functions are performed on the host platform via the cable, to maintain vehicle simplicity. The vehicle homes in on and docks with a reusable Socket autonomously, completing the connection between the host platform and the outside world. The Socket provides both acoustic and optical homing aids, as well as the latching mechanism required for the wet-mate optical connection. After the data transfer is complete, the plug detaches from the socket and may either be scuttled or retrieved for refurbishment. The Flying Plug was demonstrated in 1996 and is a key part of the Distributed Surveillance Sensor Network (DSSN). The objective of DSSN is to investigate the applicability of using small, inexpensive undersea vehicles for surveillance applications and submarine connectivity. Autonomous undersea vehicles gather data and periodically dock with undersea stations to dump data, recharge batteries, and receive new instructions. The data is retrieved by way of the Flying Plug providing the critical communications link to the Fleet



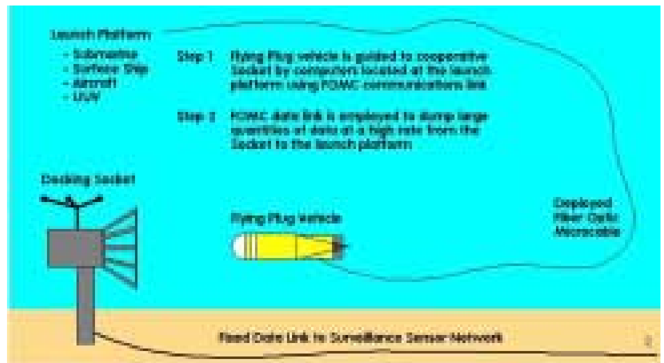


Figure 4: The Flying Plug

C. Implementers

After the data has been collected, communicated to the central nodes, and processed, it is often desirable to be able to act upon it in a timely and appropriate fashion. Typical military actions may include firing on a target, intercepting a target, retrieving an object, or neutralizing a threat. Some of these functions are already routinely performed by autonomous systems: witness the use of torpedoes and cruise missiles. Nonetheless, the field is wide open for the expansion of autonomous work capabilities.

Autonomous undersea work is still in its infancy, but much ground has been covered by remotely operated systems such as the Advanced Tethered Vehicle (ATV) and the Mine Neutralization System (MNS). The neutralization capabilities of the MNS can now be performed by one-shot disposable systems such as the Archerfish and SeaFox. With the continuing development of small AUVs, autonomous mine neutralization is not far off. General work tasks are more difficult to perform autonomously due to their more complex and relatively unpredictable nature. However, as systems are designed for use with autonomous vehicles, more complex operations will be possible, further enhancing overall capabilities.

III. UUV SURVEILLANCE TECHNOLOGIES

Along with the platforms themselves, there are some key technologies that must be considered for unmanned ISR missions, in particular: sensors, underwater communications, and autonomous behavior.

A. Sensors

As the key part of ISR consists of collecting information, the sensors drive the overall capabilities of a system. The effective use of UUVs requires that sensors be small size, low power systems, able to be deployed easily. The use of micro-circuitry and miniaturized components, such as in the sensors shown in Figure 5, are continually improving the capability of UUV based systems.

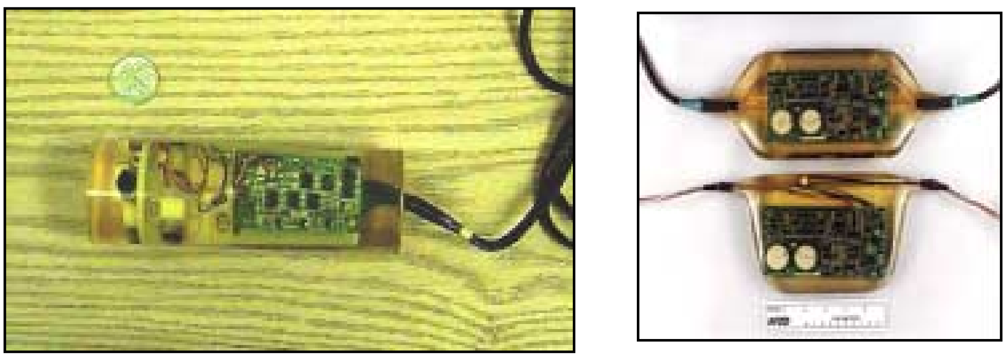


Figure 5: Miniature Magnetic and Acoustic Sensors

B. Communication Technologies

The undersea environment presents extreme challenges in communication in terms of rate, bandwidth, and covertness. The communication modality must be chosen with consideration to both the performance zones of the available technologies and the mission requirements of stand-off distance and data rates (Figure 6).

Efforts at SSC-SD have been directed at providing high data rate transmissions for C3I (command, control, communications, intelligence) missions, real time communications links across platforms, and data recovery from undersea sensor packages. To these ends, both acoustic and fiber optic based systems have been developed. In support of the AUSS vehicle, a vertical path acoustic telemetry system was delivered with a range of 10 km and a data rate of 1200-4800 bits/ second. An acoustic diversity telemetry system was also developed and transferred to industry where it was used with other vehicle systems. The use of fiber optic micro-cable was pioneered at SSC-SD with the development of the production process, followed by its incorporation into several systems including the Nearterm Mine Reconnaissance System (NMRS).

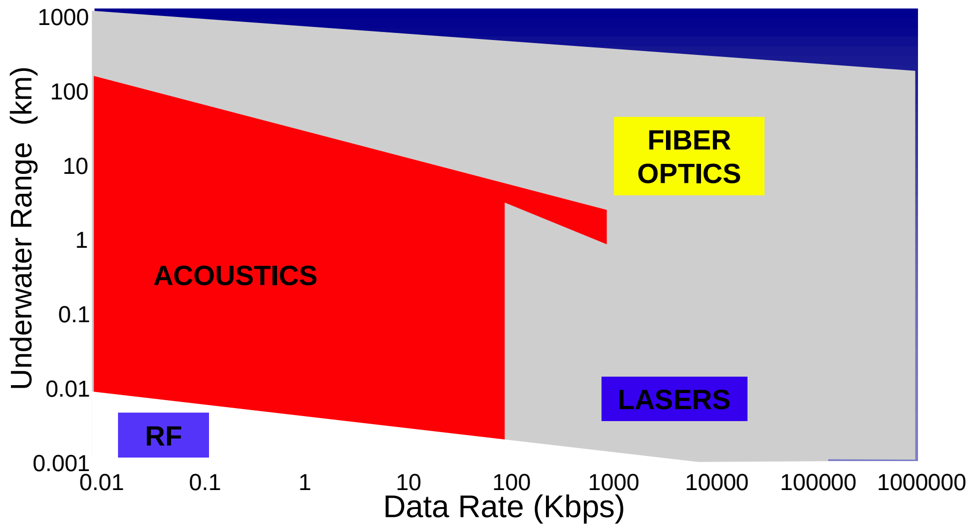


Figure 6: Undersea Communication Technologies [Brininstool]

C. Autonomy

Today's unmanned vehicle systems are showing increasing levels of autonomy, enabling them to perform complex missions with minimal human intervention. Figure 7 shows a representative sampling of UUVs today reflecting their task complexity versus the degree of human control required. Autonomy is of particular importance for many ISR roles, where it is critical that the vehicle system be able to function independently, minimizing the risk to manned platforms.

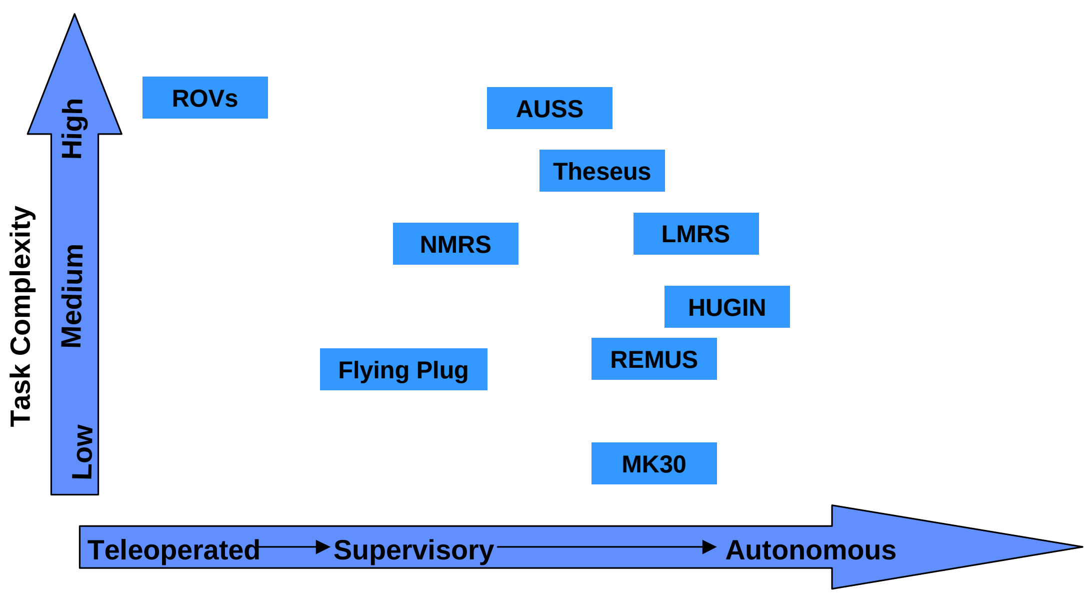


Figure 7: Relative Autonomy of Today's UUVs

IV. CONCLUSIONS

Unmanned underwater vehicles can and are playing ever increasing roles in Intelligence, Surveillance, and Reconnaissance. The extended range and covertness of autonomous sensor platforms allow collection of data from ever increasing areas. Communication of the data between platforms can be enhanced by use of UUVs, leading to more complete and efficient data collection and processing. Finally, the ability to perform various tasks autonomously will continue to develop with vehicles as integral parts of the battlespace network.

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NOTE

The systems discussed are related to the subject matter of one or more U.S. Patents assigned to the U.S. Government, including Patent No. 4,857,912; 5,034,817; 5,111,401; 5,202,661; 5,493,273; 5,659,779; and 5,812,267. Licensing inquiries may be directed to:

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